EFFECTIVE DOSE FROM DIAGNOSTIC NUCLEAR MEDICINE PROCEDURES IN NORTHERN GREECE

Konstantinos A. Hatziioannou[1], A. Hatzigiannaki[1], E. Molyvda-Athanasopoulou[2], A. Sioundas[2], P. Kostaki[3] and K. Psarrakos[2]

[1] Medical Physics Department, AHEPA General Hospital, Thessaloniki, Greece
[2] Medical Physics Lab., Medical School, Aristotle University of Thessaloniki
[3] Medical Physics Department, Theagenio Anticancer Hospital, Thessaloniki

INTRODUCTION

To estimate total radiation risk of diagnostic medical procedures, epidemiological studies are necessary. Concerning nuclear medicine investigations, only a few studies have been published in the literature (1,2). Furthermore in Greece, the number of nuclear medicine examinations has been increased during the last five years while new radiopharmaceuticals (^{131}I MIBG, ^{201}Tl chloride, ^{67}Ga citrate, etc) and new techniques are available.

A term that permits the comparison of exposure of patients undergone different medical examinations using ionising radiation is the effective dose, E. According to the recommendations of I.C.R.P. (3), the probability of stochastic effects depends not only on the absorbed dose but on the type and energy of radiation and the tissue irradiated, as well. This is taken into account by weighting the absorbed dose for radiation quality and for the relative contribution of that organ to the total detriment. The doubly weighted absorbed dose is called effective dose, E, and has replaced the previously used effective dose equivalent, E.D.E.

Minor changes have been applied to tissue weighting factors, w_T which resulted in reduction of effective dose from radiopharmaceuticals labelled with ^{99m}Tc and in increase of effective dose from iodide radioisotopes.

MATERIALS AND METHODS

Effective dose per MBq was calculated for a number of radiopharmaceuticals commonly used in nuclear medicine procedures. The calculations referred to adults of equal numbers of both sexes. For that reason for gonads we used the mean value of absorbed dose of testes and ovaries.

Effective dose is expressed by the formula

$$E=\sum_T w_T.H_T = \sum_T w_T \sum_R w_R.D_{T,R}$$

where w_T is the tissue weighting factor, H_T is the equivalent dose in a tissue or organ, w_R is the radiation weighting factor and $D_{T,R}$ is the mean absorbed dose over tissue T caused by radiation R.

The radiation weighting factor, w_R was taken equal to unity for all the γ, X and beta emitting radionuclides (3). To estimate the effective dose for a radiopharmaceutical, the absorbed dose $D_{T,R}$ was multiplied by the relative tissue weighting factor, w_T and the products were summed. Data regarding the mean absorbed doses per organ, $D_{T,R}$ for each one of the radiopharmaceuticals was taken from ICRP 53 (4), except for ^{99m}Tc sestamibi. Data for this radiopharmaceutical was taken from a description of a commercial kit.

We considered that the remainder consisted of the following tissues and organs: adrenals, muscle, pancreas, spleen, kidney, brain, upper large intestine, small intestine and uterus. To each of them, except uterus, we attributed a weighted factor of 0.0059. In the case of uterus (half population) the weighing factor was 0.0029. In exceptional cases, in which one of the remainder receives an equivalent dose in excess of the highest dose in any of the twelve organs, a weighting factor of 0.025 was applied to that tissue and a weighting factor of 0.025 to the average dose in the rest of the remainder.

The data concerning the number and the type of nuclear medicine examination used in this study, has been collected from the nuclear medicine departments of the hospitals AHEPA, Ippokratio and Theagenio, which cover all the nuclear medicine procedures done in public hospitals in Thessaloniki, second largest city in Greece. The number of examinations was 50102 during the period 1990-1994.

RESULTS

Effective dose per MBq of administrered radiopharmaceutical was calculated based on data from ICRP 53 and ICRP 60. The values of effective dose, E, are given in table 1. Effective dose equivalent (E.D.E.) values published in ICRP 53 are also given for comparison. The effective dose (E) values are compatible with those calculated by other investigators (5).

Table 1 also contains the type of examination/organ, the radiopharmaceutical used, the range of activities administered, the number of examinations, the value of E.D.E. and effective dose, E, and the collective E.D.E. and collective effective dose, S, in man-Sv.

Table 1. Effective dose per MBq of administrered radiopharmaceutical, collective E.D.E. and collective effective dose, S, from all examinations.

Exanination Organ	Radiopharmaceutical	Activity (MBq)	Number of examinations	% of total examinations	E.D.E (mSv/MBq) ICRP 26	E (mSv/MBq) ICRP 60	Collective E.D.E. (man-mSv)	Collective effective dose, S (man-mSv)	% of S
Thyroid	^{99m}Tc pertechnate	74-111	13660	27,26	0,013	0,013	18069	18069	13,50
Parotid gland	^{99m}Tc pertechnate	148-185	75	0,15	0,013	0,013	151	151	0,11
RBC	^{99m}Tc pertechnate	629-740	566	1,13	0,013	0,013	5146	5146	3,85
Meket	^{99m}Tc pertechnate	185	56	0,11	0,013	0,013	135	135	0,10
Bone	^{99m}Tc phosphonates	740	11750	23,45	0,008	0,006	69560	52170	38,98
Liver/Spleen	^{99m} Tc colloid	130-148	13584	27,11	0,014	0,01	26868	19192	14,34
Kidney	^{99m} Tc DTPA	259-296	4295	8,57	0,0063	0,0055	7716	6736	5,03
Kidney	^{99m} Tc DMSA	148	924	1,84	0,016	0,009	2188	1231	0,92
Brain	^{99m} Tc DTPA	740	187	0,37	0,0063	0,0055	872	761	0,57
Brain	^{99m}Tc pertechnate	740	450	0,90	0,013	0,013	4329	4329	3,23
Lung ventilation	^{99m} Tc DTPA	74	154	0,31	0,007	0,0063	80	72	0,05
Biliary	^{99m} Tc IDA	185-259	655	1,31	0,024	0,015	3182	1989	1,49
Lung perfusion	^{99m} Tc MAA	148-185	893	1,78	0,0012	0,0012	1632	1632	1,22
Red marrow	^{99m} Tc nanocolloid	370	45	0,09	0,014	0,01	233	167	0,12
Lymph nodes	^{99m} Tc microcolloid	74	156	0,31	0,014	0,01	162	115	0,09
Heart	^{99m} Tc Sestamibi	740	72	0,14	0,0043	0,0012	229	64	0,05
Vitamin B12 abs.	^{57}Co vitamin B12	0,019	195	0,39	2,7	2,2	10	8	0,01
Vitamin B12 abs.	^{58}Co vitamin B12	0,019	195	0,39	5,1	4,2	19	16	0,01
RBCV*	^{51}Cr chloride	2,22	315	0,63	0,11	0,074	77	52	0,04
RCST**	^{51}Cr chloride	4 - 5,55	184	0,37	0,11	0,074	97	65	0,05
Kidney	^{51}Cr EDTA	1,85	150	0,30	0,0023	0,0021	1	1	0,00
Ga-67	^{67}Ga citrate	155-185	268	0,53	0,12	0,11	5237	4800	3,59
Plasma volume	^{125}I HSA	0,11	315	0,63	0,34	0,28	12	10	0,01
Kidney	^{131}I hippuran	2,0-6,0	215	0,43	0,066	0,055	40	33	0,02
Adrenals	^{131}I MIBG	19	32	0,06	0,2	0,15	122	91	0,07
Thyroid-uptake	^{131}I iodide	1,11-1,85	420	0,84	15	25,1	6416	10736	8,02
Heart	^{201}Tl chloride	74-111	291	0,58	0,23	0,21	6553	5983	4,47
Total			50102	100			159135	133752	100

* Red Blood Cell Volume ** Red Cell Survival Time

The mean value of E.D.E. is 3.18 mSv per examination and the mean value of effective dose, is 2.67 mSv per examination. The frequency of examinations in effective dose range is shown in figure 1.

DISCUSSION

The collective effective dose compared to collective E.D.E. appears to be decreased, due to the different weighting factors. We must notice that effective dose from ^{131}I, which is used for thyroid uptake tests, is remarkably increased. Thyroid uptake with ^{131}I represents only 0.8% of the total number of examinations, but due to the relatively large radiation dose per investigation, contributes to the 8% of the collective effective dose. We should also mention that thyroid scans with ^{99m}Tc are 27.3% of the number of examinations, but its relative contribution is limited to 13.5% of collective effective dose.

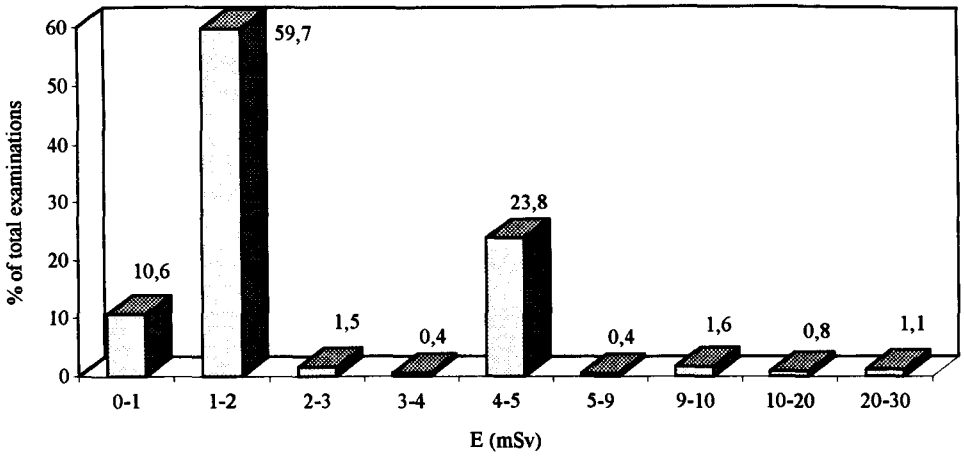

Figure 1. Percentage of examinations in effective dose range.

Although the nuclear medicine diagnostic procedures performed at the three hospitals are twenty eight in total, 80% of the collective effective dose, S, is due only to five types of investigations (thyroid, bone, liver/spleen, kidney-DTPA and thyroid uptake), which correspond to the 87% of the total nunber of examinations. Furthermore, bone scans contribute to 39% of the collective effective dose.

Various nuclear medicine examinations result to different effective dose values, but as it can be seen from figure 1, the 70% of the examinations corresponds to 0-2 mSv and the 24 % of them, due mainly to bone scans, corresponds to 4-5 mSv.

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